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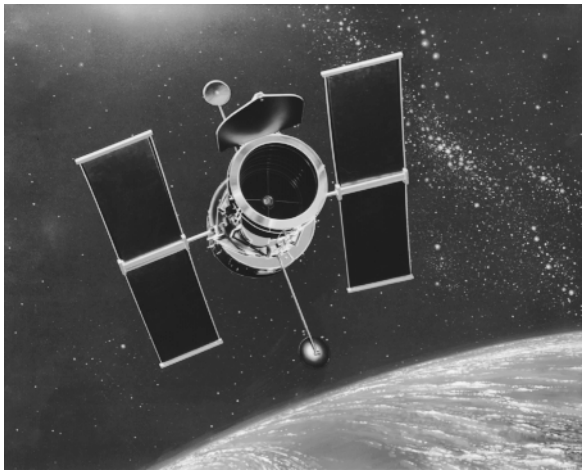
This artist's concept shows the open end of NASA's Hubble Space Telescope as it orbits the Earth. The more than 12-ton unmanned telescope was designed to see deeper into space than ever before. Marshall Space Flight Center has responsibility for the Hubble Space Telescope project.



Hubble Space Telescope

Long before mankind had the ability to go into space, astronomers dreamed of placing a telescope above Earth's obscuring atmosphere. In 1923, the German scientist Hermann Oberth proposed an observatory in space. Oberth's work inspired Wernher von Braun's interest in space travel.

Scientific instruments installed on early rockets, balloons, and satellites in the late 1940's through the early 1960's produced enough exciting scientific revelations to hint at how much remained to be discovered.

In 1962, just 4 years after NASA was established, a National Academy of Sciences study group recommended the development of a large space telescope as a long-range goal of the fledgling space program. Similar groups repeated the recommendation in 1965 and 1969.

NASA assigned responsibility for design, development, and construction of the large space telescope to the Marshall Center. Marshall selected two primary contractors to build the Hubble Space Telescope. Perkin-Elmer Corporation in Danbury, Connecticut, was chosen to develop the optical system and guidance sensors. Lockheed Missiles and Space Company of Sunnyvale, California, was selected to produce the protective outer shroud and the spacecraft systems for the telescope, as well as to assemble and test the finished product.

Beyond assigning project contracts, Marshall managed hardware and assembly preparations. The Center also worked to define the project's science and engineering requirements. Marshall crew systems experts developed the tools, workstations, and procedures which would be needed for orbital servicing of the telescope, and conducted numerous tests of orbital maintenance and repair techniques using Marshall's Neutral Buoyancy Simulator. Marshall's technical resources were also tapped for everything from the telescope's structural engineering to its fine guidance sensors.

Later, Marshall Center's involvement continued as the facility's personnel played key roles in tests of the observatory on the ground and on the launch pad—the latter monitored from Marshall's Huntsville Operations Support Center. The Marshall Center also managed the activation and orbital verification of the telescope and science instruments from Goddard Space Flight Center during Hubble's first several months in orbit.

Construction and assembly of the space telescope was a painstaking process that spanned almost a decade. The precision-ground mirror was completed in 1981, and the optical assembly was delivered for integration into the satellite in 1984. The science instruments were delivered for testing at NASA in 1983. Assembly of the entire spacecraft was completed in 1985.

Launch of the Hubble Space Telescope was originally scheduled for 1986. It was delayed during the Space Shuttle redesign that followed the *Challenger* accident. Engineers used the interim period to subject the telescope to intensive testing and evaluation, ensuring the greatest possible reliability.

The telescope was shipped from Lockheed in California to the Kennedy Space Center in Florida in October 1989. There, it was launched aboard the STS–31 mission of the Space Shuttle *Discovery* on April 24, 1990.

The Hubble Space Telescope, with a resolving power calculated to be 10 times better than any telescope on Earth, was poised to open a new era in astronomy. Within a few months, however, a flaw was discovered in Hubble's main mirror that significantly reduced the telescope's ability to focus.

The focusing defect was due to spherical aberration, an optical distortion caused by an incorrectly shaped mirror. The mirror was too flat near the edge by about 1/50th the width of a human hair. Instead of being focused into a sharp point, light collected by the mirror was spread over a larger area in a fuzzy halo. Images of objects such as stars, planets and galaxies were blurred. However, on relatively bright objects, Hubble's cameras were still able to provide images far superior to any telescope on the ground.

The mirror itself couldn't be fixed or changed; so the challenge facing NASA was to develop corrective optics for Hubble's instruments, much like eyeglasses or contact lenses correct human sight.

On December 2, 1993, the STS–61 crew launched on Space Shuttle *Endeavour* for an 11-day mission with a record five spacewalks planned. The astronauts endured long hours of challenging spacewalks to install instruments containing the corrective optics and replaced the telescope's solar arrays, gyroscopes, and other electronic components. The crew completed everything it set out to do and the mission was declared a success. After 5 weeks of engineering checkout, optical alignment and instrument calibration, the confirmation of success came as the first images were received on the ground from the space telescope.

In February 1997, STS–82 astronauts on board *Discovery* conducted a second Hubble servicing mission during a 10-day flight. The objective of the mission was to significantly upgrade the scientific capabilities of the Hubble Space Telescope with the installation of two state-of-the-art instruments. The astronauts also performed routine maintenance and installed several makeshift insulating blankets to protect the observatory's delicate instruments from temperature extremes.

Space Shuttle servicing mission (STS–103) in December 1999 restored NASA's premier optical space observatory to full capability beefed-up with new electronics and critically needed replacement gyroscopes.